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A PROGRESS REPORT
MONITORING OF
VEGETATION AND SOIL
IN THE
SPRUCE POINT MINE DISCHARGE SITE
1980 - 1981

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ERRATA:

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To Distribution List:

All units of concentration of the metals on pages 5 (para 1 and 2), 6 (para 1), 7 (para 4), 8 (para 1 and 2) and 9 (para 1) should read µg/g instead of mg/g.

EXECUTIVE SUMMARY

Monitoring of Vegetation and Soil in Spruce Point Mine Discharge Site, 1980 - 1981

Spruce Point Mine (owned and operated by Hudson Bay Mining and Smelting Co. Ltd.) located on the south shore of Reed Lake has been in operation for approximately 3 years, and is discharging wastewater into a 6 hectare swamp area located south of Highway # 391 (approximately 7.5 km from the mine site). The wastewater consists of treated sewage, mine water and compressor cooling water.

Sampling was carried out in 1980 and 1981 to investigate the accumulation and distribution of effluent contaminants in the Spruce Point Mine Discharge Site. Vegetation and soils were sampled at 22 locations within the discharge site and site inspections were carried out. Samples were analyzed for lead, copper, zinc, nickel, cadmium, iron, mercury, and arsenic.

Results showed that concentrations of lead, copper and zinc in soils increased since discharge to the site began in 1980. Although very high levels of iron were found in some samples, the iron in soil data were judged to be suspect and were not used in the assessment. The highest lead, copper and zinc readings occurred near the discharge point at the end of the pipe and the general pattern of accumulation took on a fan shape to the east of the effluent outfall. The primary outflow from the site is at the east end and the pattern described above is consistent with the general flow pattern.

The heavy metal content of the vegetation could not be used to determine distribution patterns of the contaminants in the discharge site; the variability was too high and there was no correlation with metal levels in the soil. The vegetation analysis results indicate that the vegetation in the swamp site does not operate as a major sink for heavy metals contained in the Spruce Point Mine wastewater.

Although large proportions of the total metal content in the effluent are probably removed by precipitation as insoluble salts or by absorption on soil colloids, it is unlikely that total decontamination is effected. Because outflow from the discharge site drains back to Reed Lake, there is potential for contaminants to reach the lake.

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I. INTRODUCTION

In the spring of 1979, the Hudson Bay Mining and Smelting Company applied under Subsection 14(1) of the Clean Environment Act, for the release of contaminants from their Spruce Point Mine, which is adjacent to Reed Lake in the Grass River Provincial Park. Following Clean Environment Commission hearings on January 21, 1980, Order No. 870 was issued, stating that, "the Applicant shall not permit the effluent to be discharged or to drain, flow or seep to the land or any body of water located north of Provincial Trunk Highway No. 391." A swamp south of highway No. 391 was selected as a discharge site for the mine wastewater because it was thought that there would be no return flow to Reed Lake from the swamp. In June 1980, the mine began to discharge approximately 100,000 - 200,000 imperial gallons per day of developmental wastewater (treated sewage, mine and compressor water), via a pipeline to the 6 hectare swamp located south of P.T.H. No. 391 (Figure 1). According to the development schedule the mine was expected to reach full production by November 1982, at which time approximately 300,000 imperial gallons/day of wastewater would be directed to the discharge site.

Terrestrial Standards and Studies initiated a vegetation and soil monitoring program in 1980 and 1981 to determine the accumulation and distribution of heavy metals received in the effluent.

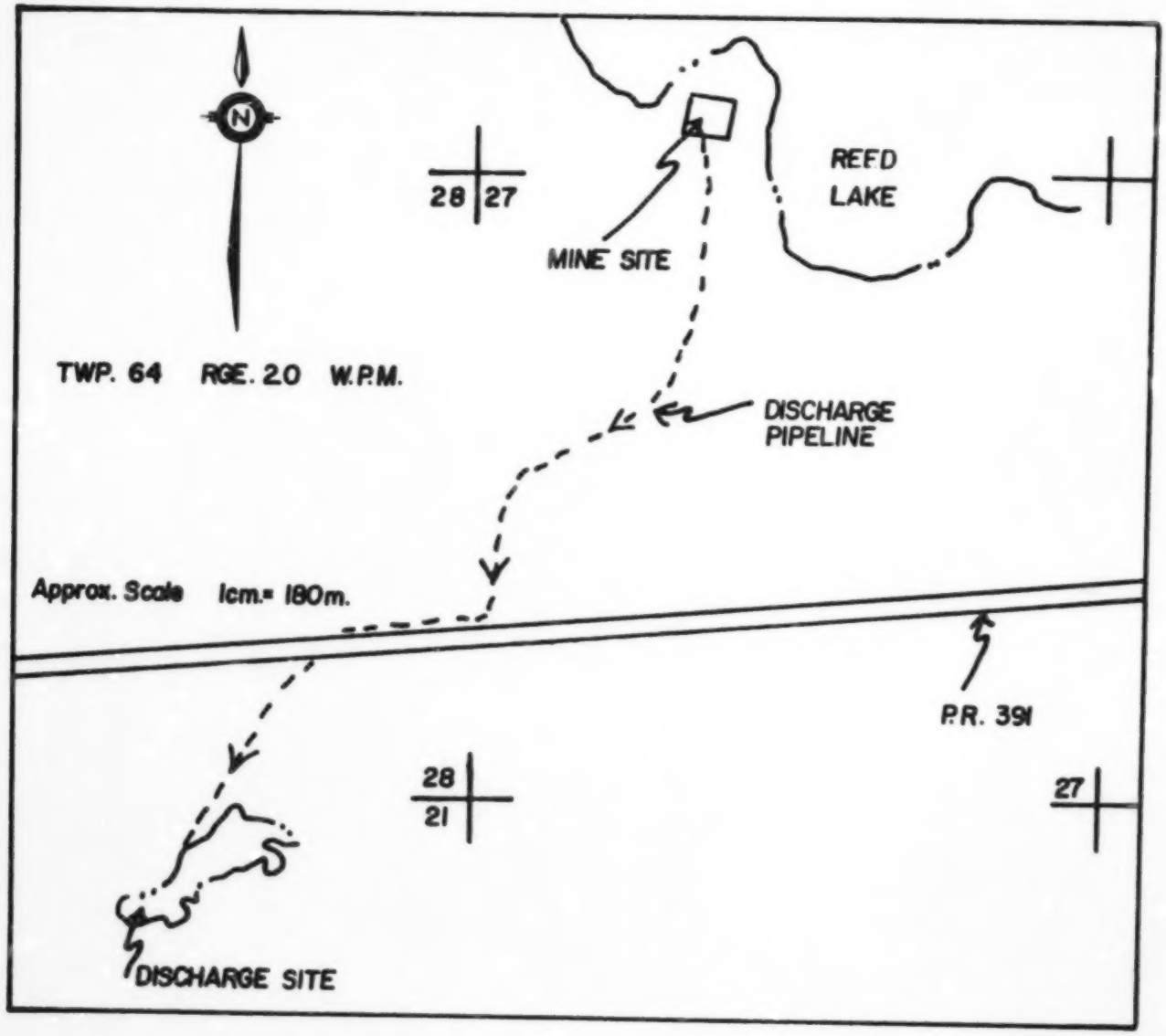

FIGURE 1: MAP OF SPRUCE POINT MINE AND DISCHARGE SYSTEM, 1980.

II. PROCEDURE

The preliminary sampling survey took place on September 2, 1980 with follow-up sampling on August 4, 1981.

The sampling design consisted of 22 stations located at 30 meter intervals along transect lines within the discharge site (Figure 2). Each station was permanently marked with an aluminum stake. At each station, a bulk sample of the dominant vegetation was collected. The dominant vegetation species were leather leaf, (Chamaedaphne calyculata) (L.) Moench), sedge (Carex spp. Laiche) and wood horsetail (Equisetum sylvaticum L.). In addition, a sample of the surface soil (8 cm layer) was collected from each sample station using a 4 cm diameter soil corer.

All samples were analyzed for Pb, Cu, Zn, Ni, Cd, Fe, Hg and As by the Technical Services Laboratory, Environmental Management Division.

III. RESULTS AND DISCUSSION

1. Soils

Soil analysis results are tabulated in Table 1 with summary data in Table 3. There was a general trend of increasing concentrations of lead, copper, zinc and iron in the surface 8 cm layer of soil in the swamp, over the period September 1980 to August 1981. It is evident from the data that the lead, copper, zinc and

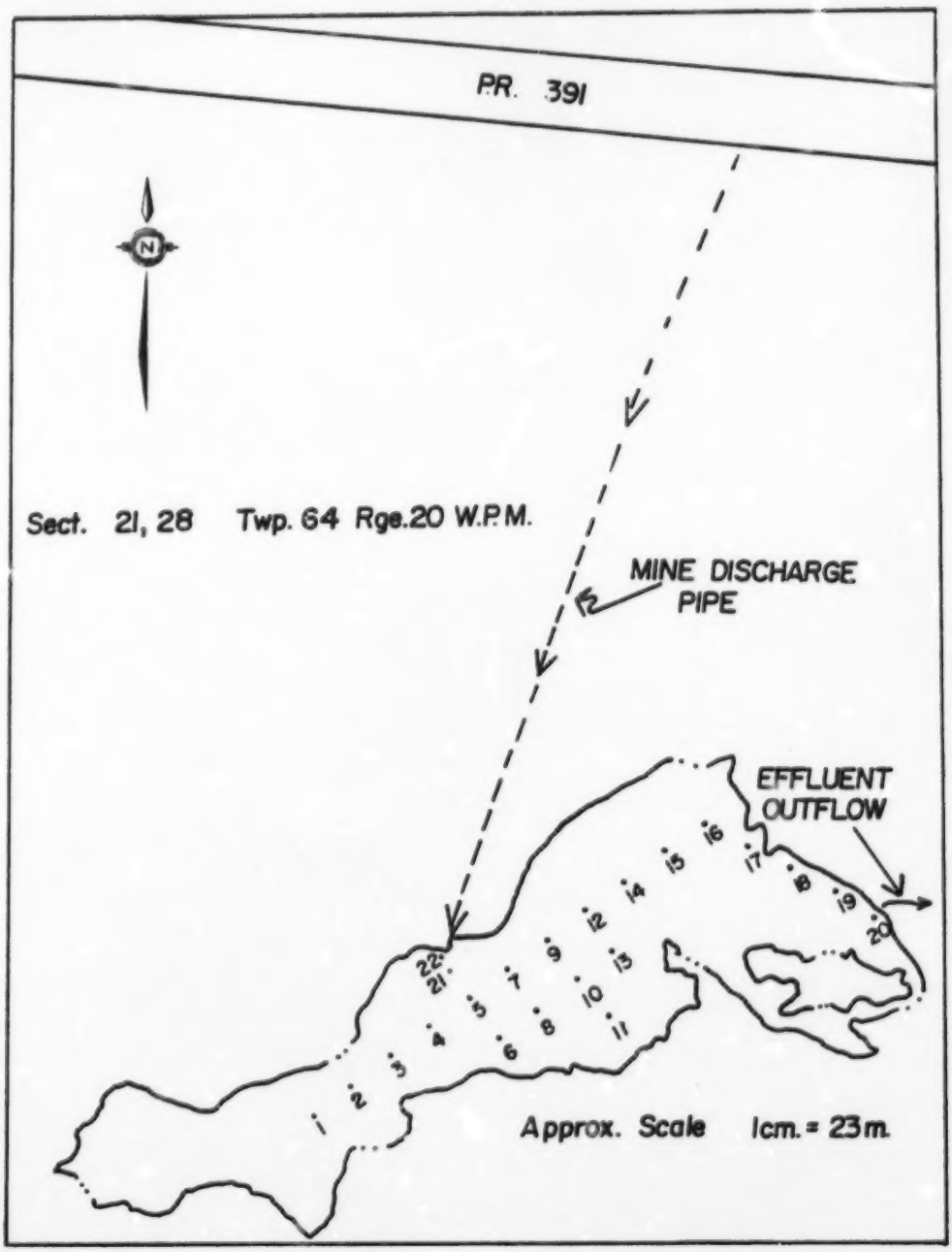

FIGURE 2: MAP OF DISCHARGE SITE SAMPLING STATIONS, 1980.

iron are contained in the effluent because the highest concentrations were found at site 22 which is adjacent to the outfall from the pipeline. The concentration of the four heavy metals also increased in the area of the swamp immediately to the east of outfall (Sites 7, 8, 9, 10, 12 and 13). The distribution pattern was consistent with the general direction of flow within the swamp, that is, toward the outflow at the east end (Figure 2).

Although most sites had increased concentrations of lead in 1981 compared with 1980, the increase was usually of small magnitude e.g. usually no more that 2 mg/g. However, significant accumulation occurred close to the effluent discharge point; at site 22 lead increased from 13 mg/g to 53 mg/g and at site 21 the increase was from 8 mg/g to 33 mg/g.

Copper concentrations in the soil of the swamp also increased at about two-thirds of the sites. At many of the sites, the increase was relatively minor, being only 2 mg/g to 6 mg/g in magnitude. As with lead, the copper concentration in the surface soil of the swamp increased dramatically at site 22, 11 mg/g to 160 mg/g and at site 21, 12 mg/g to 80 mg/g. Concentrations also increased significantly in an area to the east of the discharge point represented by sites 7, 8, 9 and 13 where concentrations in 1980 were in the 8 to 10 mg/g range and increased to a range of 21 to 36 mg/g in 1981.

Very large increases in the zinc levels in soils close to the discharge point were found over the period September 1980 to August 1981. There was a 28 fold increase in zinc at site 22 (36 mg/g to 1025 mg/g); the increase at site 21 was also substantial (65 mg/g to 569 mg/g). The zinc concentration at sites 5 and 9 tripled while at sites 7 and 8, it doubled. There were only two sites, 14 and 19, where the zinc concentration did not increase; marked increases were found at all other sites.

The distribution pattern of iron in soil from the effluent is not clear because of the occurrence of abnormally high readings at some sites compared with adjacent sites closer to the outfall. Sites 6, 16, 20 and 22 had abnormally high iron concentrations in the September 1980 soil samples, while unexpectedly high levels were found at sites 6, 8, 9, 11, 12 and 17 in the August 1981 samples. The reason for these anomalous data is not known. Other sites within the area of the swamp immediately east of the outfall (21, 7, 10, 13 and 14) had increased iron concentrations which suggest an accumulation from the mine effluent. However, because of the suspect data at adjacent sites, the iron data cannot be used to define a distribution pattern. There was no indication that nickel or cadmium are accumulating in the discharge site which suggests that there are only minor quantities in the mine wastewater. Comparison data from 1980 and 1981 are not available for mercury and arsenic respectively and therefore no assessment of their deposition was possible.

Table 3 supports the detailed results in that the average concentration of lead, copper, zinc and iron within the discharge site increased from 1980 to 1981. However, as indicated in the preceeding discussion, the dispersion within the discharge site is not uniform but rather takes on a general fan shaped pattern to the east of the discharge point.

These data indicate that lead, copper and zinc which were present in the mine wastewater has been absorbed to soils within the discharge site. The efficiency of the absorption process is not known. It is unlikely that all of the metal were bound to soil colloids and therefore outflow water from the east end of the discharge site probably contained dissolved heavy metals.

2. Vegetation

The vegetation samples collected from each site was a variable mixture of three species, leather leaf, sedge and wood horsetail. The vegetation chemical analysis data is presented in Table 2 with summary data in Table 3.

Overall, the content of heavy metals in the aboveground plant parts does not correlate well with the concentration of metals found in the soil samples. Site 22 was an exception in that between 1980 and 1981, the concentration of zinc in the vegetation was elevated from 50 to 76 mg/g and the iron level increased from 170 to 1436 mg/g.

There was no change in the lead levels in the vegetation which could be attributed to the mine wastewater. In fact, lead levels were lower in 1981 than in 1980, albeit, that was of little significance because concentrations were low, e.g. maximum lead level was 4.0 mg/g.

Copper concentrations in the vegetation were similar between 1980 and 1981. Although slightly elevated levels were found in 1981 samples compared with 1980, the increase could be demonstrated in only 50 percent of the samples and these were randomly distributed over the dicharge site. Furthermore, the differences were relatively small, 1.2 mg/g or less and the mean copper concentration in all vegetation samples was not significantly different between the two years (Table 3).

Of all the metals analyzed, zinc shows the strongest correlation with the soil results. The concentration of zinc in vegetation increased in sites close to the effluent outfall (22 and 21) as well as in the area immediately south and east of the discharge point (5, 6, 7, 8, 10, 12, 13 and 14). Thus, the distribution is consistent with the fan shaped pattern identified from the soil analysis data. In spite of that, the data were highly variable so that the increases at the sites mentioned above were matched by similar decreases at the other sites. The net result was that the average zinc concentration in the vegetation of the entire discharge site was slightly lower in 1981 than in 1980 (not statistically significant).

Iron levels in the vegetation increased at all but five sites within the discharge area. However, the data were highly variable with high and low concentrations and large and small increases, which occurred at random. There was no consistent pattern of iron levels in the vegetation which would enable one to identify the source. For example, there was a relatively large increase in iron at site 22 from 170 mg/g in 1980 to 1436 mg/g in 1981. However, the concentration at site 21 which was only a short distance away remained relatively constant at 78 and 73 mg/g respectively. On the other hand, the iron concentration at site 20 which was farthest away from effluent discharge point, increased dramatically from 190 mg/g to 731 mg/g. Furthermore, there was no correlation between iron-in-vegetation and iron-in-soil data.

There was no indication that nickel and cadmium levels in the vegeation have been affected by the mine water discharged to the site. This was to be expected since there was no indication in the soils data that nickel and cadmium were present as contaminants in the wastewater.

Overall, vegetation uptake of heavy metals did not occur in proportion to the soil concentration. This result is not uncommon because uptake of ions by plants is a complex phenomenon which is difficult to predict even in strictly controlled experiments; soil factors or physiological processes within the plant or combinations of both may affect the absorption rate.

In conclusion, the vegetation chemical analysis data indicate that vegetation in the discharge site does not function as a major sink for heavy metals contained in the Spruce Point Mine wastewater. It also follows that, in this instance, levels of heavy metals in vegetation was not a good indicator of heavy metal distribution in the discharge site.

3. Surface Hydrology

The water table/water level of the discharge site has been steadily increasing since the mine went into operation. The water table increased so dramatically between 1981 and 1982 that ongoing sampling of soils and vegetation within the discharge site was cancelled in 1982. Air photo interpretation was used to identify potential drainage pathways from the discharge site back to Reed Lake. Subsequent ground truthing of the area in July 1980 confirmed that the primary outflow at the east end of the swamp does drain back to Reed Lake. Flow through the culverts on highway 391 is at a maximum during the spring runoff, decreasing to minimal flows during the remainder of the open water season. It is possible that a portion of the outflow from the discharge site enters the groundwater system before reaching the highway.

4. CONCLUSIONS

Concentrations of lead, copper and zinc increased in the surface soil of the discharge site (swamp) over the period September 1980 to August 1981. The greatest accumulation occurred near the discharge pipe and dispersion has occurred in a fan shaped pattern to the east of the effluent outfall.

Uptake of the heavy metals by vegetation cannot be confirmed and therefore the vegetation is discounted as a mjor sink for the wastewater contaminants.

Although large proportions of the total metal content in the effluent are probably removed by precipitation as insoluble salts or by adsorption in soil colloids, it is unlikely that total decontamination is affected. Therefore, the outflow may contain dissolved heavy metals.

Aerial photography and site inspections indicate that drainage from the discharge site returns to Reed Lake, thus creating the potential for contaminants to reach the lake.

TABLE 1: Heavy Metal Content in Soil (µg/g) from the Spruce Point Mine Discharge Site, 1980 and 1981.

STATION NUMBER	Pb		Cu		Zn		Ni		Cd		Fe		Hg		As	
	80	81	80	81	80	81	80	81	80	81	80	81	80	81	80	81
1	8.0	10.0	13.0	28.0	70.0	93.0	14.0	11.0	2.0	2.0	2400	2800	<0.02	0.06	2.00	
2	10.0	13.0	18.0	19.0	100.0	181.0	18.0	11.0	2.0	1.0	3300	2500	<0.02	0.07	2.21	
3	13.0	13.0	17.0	19.0	84.0	168.0	16.0	11.0	2.0	1.0	3100	1900	<0.02	0.05	2.12	
4	8.0	10.0	17.0	15.0	84.0	125.0	18.0	11.0	2.0	1.0	5900	4700	<0.02	0.06	1.72	N
5	5.0	13.0	29.0	17.0	51.0	187.0	16.0	5.0	2.0	1.0	4400	1600	<0.02	0.06	2.25	O
6	13.0	10.0	21.0	18.0	47.0	75.0	38.0	40.0	2.0	1.0	22000	25200	<0.02	0.02	4.11	
7	8.0	10.0	8.0	23.0	40.0	100.0	14.0	11.0	2.0	1.0	3600	5000	<0.02	0.07	2.25	A
8	8.0	27.0	8.0	36.0	51.0	100.0	12.0	57.0	2.0	1.0	2400	31700	<0.02	0.02	1.48	M
9	5.0	7.0	10.0	29.0	27.0	81.0	12.0	17.0	2.0	1.0	4200	9300	<0.02	0.03	1.96	A
10	5.0	<5.0	9.0	13.0	45.0	62.0	10.0	8.0	2.0	1.0	2700	3700	<0.02	0.08	1.52	L
11	8.0	13.0	28.0	21.0	62.0	93.0	12.0	20.0	2.0	1.0	2100	12400	<0.02	0.07	1.67	Y
12	8.0	10.0	12.0	18.0	24.0	75.0	14.0	20.0	2.0	1.0	4200	12400	<0.02	0.03	1.47	S
13	8.0	7.0	8.0	21.0	29.0	56.0	12.0	8.0	2.0	1.0	2800	5000	<0.02	0.07	1.47	I
14	5.0	7.0	10.0	17.0	36.0	31.0	14.0	8.0	2.0	1.0	2500	3700	<0.02	0.05	1.29	S
15	8.0	10.0	19.0	19.0	14.0	25.0	18.0	8.0	2.0	1.0	5600	5600	<0.02	0.06	1.61	
16	15.0	<5.0	22.0	23.0	84.0	131.0	43.0	20.0	2.0	1.0	22000	5600	<0.02	0.04	1.57	
17	8.0	27.0	13.0	27.0	54.0	100.0	14.0	46.0	2.0	1.0	4600	35000	<0.02	0.02	1.47	D
18	8.0	10.0	11.0	14.0	44.0	69.0	12.0	5.0	2.0	1.0	4700	5000	<0.02	0.06	1.67	O
19	8.0	10.0	19.0	15.0	57.0	44.0	12.0	8.0	2.0	1.0	4100	5600	<0.02	0.06	1.94	M
20	10.0	<5.0	7.0	17.0	46.0	75.0	35.0	11.0	2.0	1.0	18000	6800	<0.02	0.08	2.12	E
21	8.0	33.0	12.0	80.0	65.0	569.0	12.0	8.0	2.0	2.0	2600	5000	<0.02	0.03	1.35	
22	13.0	53.0	11.0	160.0	36.0	1025.0	35.0	32.0	2.0	2.0	10000	20500	<0.02	0.09	1.50	

TABLE 2: Heavy Metal Content in Vegetation (µg/g) from the Spruce Point Mine Discharge Site, 1980 and 1981.

STATION NUMBER	Pb		Cu		Zn		Ni		Cd		Fe		Hg		As	
	80	81	80	81	80	81	80	81	80	81	80	81	80	81	80	81
1	4.0	<1.0	3.2	3.4	76.0	52.0	3.2	7.0	0.40	.25	150.0	88.0		<0.02	0.21	
2	3.0	<1.0	3.2	4.2	66.0	57.0	3.2	2.0	0.40	.25	240.0	391.0		<0.02	0.79	
3	2.6	<1.0	2.0	2.8	46.0	49.0	3.2	3.0	0.40	.25	120.0	151.0		<0.02	0.11	
4	3.6	<1.0	4.8	2.0	70.0	35.0	3.2	1.0	0.40	.25	180.0	93.0	N	<0.02	0.26	N
5	3.0	<1.0	3.6	3.6	32.0	48.0	2.0	3.0	0.40	.25	90.0	111.0	O	<0.02	0.18	O
6	2.0	3.0	3.2	3.0	25.0	27.0	2.0	<1.0	0.40	.25	56.0	106.0		<0.02	0.09	
7	2.0	2.0	2.2	3.4	11.0	27.0	<1.0	2.0	0.40	.25	52.0	91.0		<0.02	0.13	
8	3.0	2.0	4.6	4.2	28.0	46.0	1.2	2.0	0.40	.25	78.0	154.0	A	<0.02	0.19	A
9	2.6	<1.0	2.4	2.8	40.0	33.0	<1.0	1.0	0.40	.25	76.0	156.0	N	<0.02	0.24	N
10	2.6	<1.0	2.8	3.6	36.0	41.0	1.6	1.0	0.40	.25	54.0	86.0	A	<0.02	0.17	A
11	3.6	<1.0	2.8	2.2	66.0	34.0	4.4	5.0	0.40	.25	200.0	141.0	L	<0.02	0.33	L
12	3.0	2.0	3.4	4.2	30.0	38.0	1.2	1.0	0.40	.25	88.0	199.0	Y	<0.02	0.05	Y
13	2.6	<1.0	3.0	2.6	22.0	38.0	<1.0	1.0	0.40	.25	74.0	124.0	S	<0.02	0.05	S
14	2.0	<1.0	3.4	4.6	46.0	49.0	2.4	3.0	0.40	.25	130.0	504.0	I	<0.02	0.17	I
15	2.6	<1.0	3.0	2.0	30.0	27.0	2.8	1.0	0.40	.25	86.0	106.0	S	<0.02	0.12	S
16	2.6	<5.0	2.8	2.6	46.0	38.0	2.4	1.0	0.40	.25	170.0	302.0		<0.02	0.13	
17	2.6	<1.0	1.8	2.6	46.0	19.0	1.6	1.0	0.40	.25	120.0	111.0		<0.02	0.19	
18	1.6	3.0	1.6	2.6	40.0	35.0	3.2	1.0	0.40	.25	94.0	517.0	D	<0.02	<0.05	D
19	2.0	2.0	3.2	2.6	38.0	33.0	2.4	1.0	0.40	.25	76.0	156.0	O	<0.02	<0.05	O
20	3.0	<1.0	4.2	2.6	46.0	30.0	1.6	2.0	0.40	.25	190.0	731.0	N	<0.02	0.17	N
21	2.0	<1.0	3.0	3.4	30.0	45.0	1.2	1.0	0.40	.25	78.0	73.0	E	<0.02	0.16	E
22	2.0	2.0	4.8	0.6	50.0	76.0	3.2	5.0	0.40	.25	170.0	1436.0		<0.02	0.17	

TABLE 3: Low, High and Mean Values of Heavy Metals (µg/g) in Vegetation and Soils from Spruce Point Mine Discharge Site, 1980 - 1981.

METALS	VEGETATION ANALYSIS						SOIL ANALYSIS					
	VALUE RANGE (µg/g)						VALUE RANGE (µg/g)					
	LOW		HIGH		MEAN		LOW		HIGH		MEAN	
	80	81	80	81	80	81	80	81	80	81	80	81
Lead	1.6	<1.0	4.0	3.0	2.6	1.50	5.0	5.0	15.0	53.0	8.6	14.0
Copper	1.6	2.0	4.8	9.6	3.1	3.39	7.0	13.0	29.0	160.0	14.6	29.5
Zinc	22.0	19.0	76.0	76.0	42.5	39.86	14.0	25.0	100.0	1025.0	52.3	157.5
Nickel	<1.0	<1.0	4.4	7.0	2.2	2.09	10.0	10.0	43.0	43.0	18.2	17.2
Cadmium	<0.40	<.25	<0.40	<.25	<0.40	<.25	<2.0	<1.0	<2.0	<2.0	<2.0	1.14
Iron	52.0	86.0	240.0	1436.0	117.0	305.77	2100.0	1600.0	22000.0	35000.0	6141.0	9590.9
Arsenic	<0.50	-	0.79	-	0.18	-	1.29	-	4.11	-	1.9	-
Mercury	-	<0.02	-	<0.02	-	<0.02	-	<0.02/.02	-	<0.02/0.09	-	<0.02/0.05

* - Samples Analyzed in Wet/Dry stage. < - less than